

# A comparison of alternative systems for measuring smoking-attributable deaths in Oregon, USA

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## Abstract

**Objective** - To determine the extent to which estimates of smoking-attributable deaths (SADs) derived from a widely used computer program, SAMMEC II, agree with an independent system, physician reporting on death certificates.

**Design** - SAMMEC II estimates were compared with physician reports of SADs in Oregon, USA, for 1989-90.

**Results** - Of 49 693 deaths in Oregon, 30 597 had underlying causes recognised by SAMMEC II as being aetiologically linked with cigarette smoking. Of these, SAMMEC II estimated that 10 351 were SADs, and physicians reported 10 072 as SADs (97% of those estimated by SAMMEC II). Physician reports and SAMMEC II estimates were similar by sex, age, and major disease category. However, SAMMEC II tended to estimate more SADs among deaths from neoplasms and fewer among deaths from heart disease and hypertension. Of the 19 096 deaths coded as having an underlying cause not generally related to cigarette smoking, physicians reported that tobacco contributed to 2067.

**Conclusions** - For specific underlying causes of death, SAMMEC II and physicians provided remarkably similar estimates of SADs in Oregon. However, SAMMEC II may underestimate SADs because it assesses only underlying and not contributory causes of death aetiologically related to cigarette smoking.

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## Background

Cigarette smoking causes more deaths in the US than any other preventable factor. It has been identified as a risk for a variety of illnesses, including cardiovascular and respiratory diseases, cancers, fetal abnormalities, and sudden infant death syndrome.<sup>1</sup> The public health importance of reducing smoking has been widely recognised, and targeted as a health objective for the year 2000.<sup>2</sup>

However, to plan, fund, and implement anti-smoking programs successfully, policy makers and the public must have a realistic sense of the disease burden caused by smoking. Public health professionals have struggled with

how best to measure this. A popular method developed by the US Centers for Disease Control and Prevention is a computer software package called "Smoking-attributable mortality, morbidity, and economic costs" software version II (SAMMEC II). SAMMEC II estimates smoking-attributable mortality, morbidity, and economic costs derived from underlying causes of death aetiologically related to smoking,<sup>3</sup> and with its predecessor SAMMEC, has been used by many states to generate smoking and health information.<sup>4-8</sup> However, SAMMEC II has not been compared with alternative systems for estimating smoking-attributable deaths (SADs).

Oregon has taken an alternative approach for measuring cigarette smoking-related mortality. Since 1989, to help quantify the influence of tobacco use on mortality, physicians have been asked to report on death certificates whether tobacco use contributed to the deaths of their patients. In this study, we determined the extent to which SAMMEC II estimates of SADs agree with those generated by an independent system, by comparing SAMMEC II estimates with physician reports of SADs in Oregon for the years 1989-90.

## Methods

### SAMMEC II ESTIMATES

SAMMEC II calculates SADs using *a*) underlying cause of death statistics for diseases causally linked to cigarette smoking, primarily derived from the 1989 Report of the Surgeon General;<sup>1,9</sup> *b*) prevalence rates among current and former smokers aged 35 years or older, and to estimate the number of perinatal deaths from smoking, smoking prevalence rates among women aged 18-44 years; and *c*) relative risks of diseases associated with smoking derived from major epidemiologic studies.<sup>3</sup> SAMMEC II operates in association with Lotus 123 spreadsheet software. It calculates smoking-attributable fractions\* - the fraction of all premature deaths that would be prevented if there were no cigarette smoke

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\* Smoking-attributable fraction is derived from the attributable risk formula: attributable risk =  $p(RR-1)/[p(RR-1)+1]$ , where  $p$  = prevalence of the risk factor, and  $RR$  = relative risk of disease in those exposed to the risk factor compared with those not exposed.

exposure. For chronic diseases, smoking-attributable fractions are only applied to deaths occurring among persons aged 35 years or older. Smoking-attributable mortality is in turn calculated from the smoking-attributable fraction multiplied by the number of deaths for each diagnosis and five-year age group for males and females. To generate SAD estimates for Oregon residents, we used mortality data for Oregon residents who died in Oregon during 1989-90, and 1988 Oregon Behavioral Risk Factor Survey smoking prevalence rates.<sup>10</sup>

#### PHYSICIAN REPORTS

Since January 1989, Oregon death certificates have included the question: "Did tobacco use contribute to the death?". Physicians certifying the death of a patient are required to check one of four possible responses to this question: yes, probably, no, and unknown. When a box is not checked, or the response does not appear logical, Health Division personnel routinely contact the certifying physician by mail to encourage its completion or correction. This occurs for about 2% of death certificates. These responses and other data on the death certificate, including demographic information, contributing causes of death recorded by the physician, and the underlying cause of death coded by Health Division staff, are entered into the Health Division's Center for Health Statistics mainframe computer database. For the purposes of this analysis, we defined physician-reported SADs as deaths among persons for whom physicians reported that tobacco contributed to or probably contributed to their deaths.

#### COMPARING SAMMEC II ESTIMATES AND PHYSICIAN REPORTS

We compared SAMMEC II estimates of SADs with physician reports of SADs in Oregon for the years 1989-90. First, we compared only deaths coded to underlying diagnoses recognised by SAMMEC II to be aetiologically linked to smoking. Second, we examined deaths for which the underlying diagnoses were not recognised by SAMMEC

II. To determine why physicians reported that some deaths from underlying causes not recognised by SAMMEC II were aetiologically related to smoking (designated non-SAMMEC II physician-reported SADs), we examined a random sample of 100 of these death certificates and 100 death certificates that neither SAMMEC II nor physicians considered smoking related.

#### Results

From January 1989 to December 1990 inclusive, 49 693 Oregon residents died in Oregon. Of these, 30 597 (62%) were coded to an underlying cause recognised by SAMMEC II as being aetiologically related to smoking. SAMMEC II estimated that 10 351 (34%) of these 30 597 deaths, or 21% of all deaths in Oregon, were attributable to smoking (table 1). Among the same 30 597 deaths, Oregon physicians identified 10 072 as SADs. The number of SADs reported by SAMMEC II was 103% of that reported by physicians. By sex, SAMMEC II estimates of SADs closely agreed with those reported by physicians: SAMMEC II estimates were 108% of physician reports among males, and 94% among females. The age distribution of SADs estimated by SAMMEC II was close to that reported by physicians, particularly among persons 45-64 years of age (SAMMEC II estimates being 110% of physician reports) and persons aged 65-84 years (SAMMEC II estimates being 91% of physician reports). SAMMEC II and physician reports were least consistent among infants, with SAMMEC II estimates more than five times those reported by physicians.

We next compared estimates from the two systems by specific underlying cause of death. SAMMEC II estimated and physicians reported similar total SADs in the major categories of disease: cardiovascular diseases, neoplasms, and respiratory diseases (table 2). By rank order, the five most common causes of death estimated by SAMMEC II were 1) neoplasms of the trachea, lung, or bronchus; 2) ischaemic heart disease; 3) chronic airways obstruction; 4) cerebrovascular disease, and 5) cardiac arrest or other heart disease. The most common causes of death reported by physicians were identical, except that the rank order of the first two were reversed. In fact, both systems reported the same nine most common specific causes of death, with only slight differences in rank order. However, there were differences in magnitude between the systems for some specific causes of death. Compared with physician reports, SAMMEC II estimated more SADs from neoplasms, with more than twice as many SADs as those reported by physicians among persons dying of oesophageal, pancreatic, cervical, and renal cancers. In contrast, SAMMEC II tended to estimate fewer deaths from heart disease and hypertension; SAMMEC II estimates of SADs from ischaemic heart disease were only 80% of those reported by physicians. The greatest discrepancies occurred for deaths from peri-

Table 1 Comparison of SAMMEC II-estimated and physician-reported smoking-attributable deaths (SADs) for underlying diagnoses aetiologically related to smoking, by sex and age, Oregon, 1989-90

	Deaths for which smoking might be a cause	SAMMEC II estimates of SADs (%)	Physician reports of SADs (%)	SAMMEC II: physician ratio
Total	30 597	10 351 (34)	10 072 (33)	1.03
Sex				
Male	15 841*	6 798 (43)	6 312 (40)	1.08
Female	14 755	3 553 (24)	3 760 (25)	0.94
Age group				
< 1	357**	54 (15)	10 (3)	5.40
1-24	49	3 (6)	2 (4)	1.50
25-44	480	196 (41)	154 (32)	1.27
45-64	4 202	2 383 (57)	2 174 (52)	1.10
65-84	17 182	5 982 (35)	6 610 (38)	0.91
85+	8 323	1 733 (21)	1 122 (13)	1.54

\* One unknown.

\*\* Four unknown.

Table 2 Comparison of SAMMEC II-estimated and physician-reported smoking-attributable deaths, by primary cause of death, Oregon, 1989-90

Disease (ICD-9 code)	All deaths	SAMMEC II estimates of SADs (%)	Physician reports of SADs (%)	SAMMEC II: physician ratio
<i>Neoplasms related to smoking</i>				
Lip, oral cavity, pharynx (140-9)	186	140 (75)	116 (62)	1.21
Esophagus (150)	223	170 (76)	77 (35)	2.21
Pancreas (157)	620	155 (25)	76 (12)	2.04
Larynx (161)	62	51 (82)	43 (69)	1.19
Trachea, lung, bronchus (162)	3560	2952 (83)	2772 (78)	1.06
Uterine cervix (180)	92	26 (28)	8 (9)	3.25
Urinary bladder (188)	253	101 (40)	70 (28)	1.44
Kidney, other urinary (189)	228	73 (32)	34 (15)	2.15
Total	5224	3668 (70)	3196 (61)	1.15
<i>Cardiovascular diseases related to smoking</i>				
Rheumatic heart dx (390-8)	174	28 (16)	28 (16)	1.00
Hypertension (401-4)	704	116 (16)	124 (18)	0.94
Ischaemic heart dx (410-4)	10895	2291 (21)	2861 (26)	0.80
Pulmonary heart dx (415-7)	184	33 (18)	39 (21)	0.85
Cardiac arrest, other HD (420-9)	3277	579 (18)	617 (19)	0.94
Cerebrovascular dx (430-8)	3915	611 (16)	624 (16)	0.98
Atherosclerosis (440)	686	258 (38)	131 (19)	1.97
Aortic aneurism (441)	470	218 (46)	149 (32)	1.46
Other arterial dx (442-8)	225	92 (41)	56 (25)	1.64
Total	20530	4226 (21)	4629 (23)	0.91
<i>Respiratory diseases related to smoking</i>				
Respiratory tuberculosis (10-2)	16	4 (25)	4 (25)	1.00
Pneumonia/influenza (480-7)	1887	469 (25)	297 (16)	1.58
Bronchitis/emphysema (490-2)	606	484 (80)	511 (84)	0.95
Asthma (493)	206	51 (25)	69 (34)	0.74
CAO (496)	1708	1361 (80)	1341 (79)	1.01
Total	4423	2369 (54)	2222 (50)	1.07
<i>Perinatal conditions related to smoking</i>				
LBW, short gestation (765)	52	10 (19)	4 (8)	2.50
Respiratory distress syndrome (769)	52	10 (19)	5 (10)	2.00
Respiratory condition, newborn (770)	39	7 (18)	2 (5)	3.50
SIDS (798.0)	220	26 (12)	0 (0)	—
Total	363	53 (15)	11 (3)	4.82
Smoking-related burns (890-9)	57	36 (63)	14 (25)	2.57
All smoking-related	30597	10351 (34)	10072 (33)	1.03
Other disease	19096	0 (0)	2067 (11)	0.00
Total	49693	10351 (21)	12139 (24)	0.85

Abbreviations: ICD-9: international classification of diseases, 9th edn; LBW: low birth weight; SIDS: sudden infant death syndrome; dx: disease; HD: heart disease; CAO: chronic airways obstruction.

natal conditions, especially for deaths from sudden infant death syndrome, where physicians reported that none were tobacco related, yet SAMMEC II estimated that 26 were associated with smoking.

Among the 49 693 total Oregon deaths, 19 096 were coded to underlying causes not recognised by SAMMEC II to be aetiologically linked to smoking. Of these, Oregon physicians reported that 2067 (11%), were SADs (designated non-SAMMEC II physician-reported SADs). These 2067 deaths represented 17% of all 12 139 SADs reported by physicians. A large number of underlying causes were represented among the non-SAMMEC II physician-reported SADs, including diabetes mellitus, malignant neoplasms of the colon, chronic liver disease and cirrhosis, non-dependent drug abuse, and alcohol dependence (table 3).

Of all 49 693 Oregon deaths during 1989 and 1990, physicians reported that 12 139 (24%) were SADs (23% in 1989 and 26% in 1990). A total of 10 072 were reported among the 30 597 deaths recognised by SAMMEC II, and 2067 were reported among the remaining deaths. SAMMEC II estimated 10 351 SADs, or 85% of the number reported by physicians.

In a random sample of 100 non-SAMMEC II physician-reported SAD death certificates, physicians reported that tobacco contributed to 40 deaths, and probably contributed to 57

deaths. Three deaths were excluded because they were miscoded during data entry; the physicians did not report that tobacco contributed to the death. Sixty (62%) of the remaining 97 death certificates listed at least one contributory cause aetiologically linked to smoking. In contrast, only 31 (31%) of a random sample of 100 death certificates recognised by neither SAMMEC II nor physicians as smoking-attributable listed contributory causes recognised by SAMMEC II. Thus, among non-SAMMEC II death certificates, physicians were more likely to have listed contributory causes recognised by SAMMEC II for deaths they reported as related to smoking than for other deaths (relative ratio = 2.0,  $p < 0.001$ ). Among the sample of 100 non-SAMMEC II physician-reported SAD death certificates, the 60 that listed a cause aetiologically linked to smoking listed significantly more contributing causes of death (mean = 3.5) than the other 37 in the sample (mean = 1.6;  $p < 0.001$ ).

## Discussion

Data on tobacco use and health are essential for developing public health programmes to discourage smoking. Although widely available and simple to use for measuring the effect of smoking on health, SAMMEC II has recognised limitations.<sup>3</sup> First, it relies on self-

Table 3 Physician-reported smoking-attributable deaths not recognised by SAMMEC II, Oregon, 1989-90

Disease group (ICD-9 code)	Physician reports	Most common specific conditions (n)
Neoplasms (140-239)	713	MN of colon (114) MN of site not specified (108) MN of prostate (77) MN of female breast (66)
Digestive diseases (520-579)	324	Chronic liver disease and cirrhosis (109) Vascular insufficiency of intestine (54)
Endocrine & other* diseases (240-279)	236	Diabetes mellitus (176)
Mental disorders (290-319)	234	Non-dependent abuse of drugs (92) Alcohol dependence syndrome (69)
Respiratory diseases (460-519)	119	Other cerebral degeneration (45)
Nervous diseases (320-389)	107	
Infectious diseases (001-139)	89	
Genitourinary diseases (580-629)	75	
Injury and poisoning (800-999)	74	
Musculo-skeletal diseases (710-739)	31	
Blood diseases (280-289)	28	
Congenital anomalies (740-759)	14	
Circulatory diseases (390-459)	11	
Skin diseases (680-709)	5	
Perinatal conditions (760-779)	5	
Complications of childbirth** (630-676)	1	
Ill-defined conditions (780-799)	1	
Total	2067	

Abbreviations: ICD-9: International classification of diseases, 9th edn; MN: malignant neoplasms.

\* endocrine, nutritional, metabolic, immunity diseases.

\*\* complications of pregnancy, childbirth, and puerperium.

reported survey data on cigarette smoking, which are subject to random variations within the surveys' confidence limits, errors in survey methodology, and underestimations of smoking prevalence.<sup>11</sup> Second, it is dependent on current smoking prevalences, while SADs often result from smoking behaviours that occurred several decades before. Third, it may be over-simplified as it does not allow for variations in the relative risk of disease by age for 25 of the 27 diseases it examines. Fourth, it does not adjust for other confounders, such as alcohol consumption and income, in its calculations.<sup>12</sup> Fifth, it is designed to be applied to populations with a mature exposure to tobacco, such as that of the US. In less developed countries where there have been more recent increases in tobacco use and where the epidemic of smoking-related deaths is at an earlier stage, SAMMEC II may not be as useful.<sup>13</sup> Sixth, it is limited by the availability of death certificates. Because of these limitations and uncertainty as to whether SAMMEC II results could be reproduced by an alternative system for measuring smoking-related mortality, it was important to compare them with physician reporting. When analysis was limited to deaths coded to specific underlying causes aetiologically linked to smoking, SAMMEC II and physicians provided remarkably similar estimates of SADs, with overall estimates within three percentage points of each other. Although both systems produced similar estimates by age, sex, and disease category, discrepancies existed for some specific causes of death, particularly those related to perinatal conditions. Some of the discrepancy among perinatal deaths may have occurred because the physician did not know the mother's smoking history, or did not consider it to be relevant to the death. Discrepancies between

SAMMEC II and physicians over neoplastic and cardiovascular deaths may reflect a misunderstanding among physicians regarding the aetiological role of smoking for some of these conditions.

When all deaths regardless of the underlying cause were considered, SAMMEC II estimated only 85 % of SADs reported by physicians. Much of the shortfall in its estimate may be explained by SAMMEC II's inability to consider all contributory causes of death. On the death certificate, the physician is asked to list up to three causes of death as well as other important conditions that were present. However, only one of these conditions is coded to the underlying cause of death (using a standard algorithm). For example, a death resulting from myocardial infarction, the underlying cause of which is listed as diabetes, is not considered by SAMMEC II even though smoking may have contributed to the myocardial infarction that led to the death. Thus, to the list of recognised SAMMEC II's limitations, we can add perhaps the most important one: that it may underestimate SADs because it assesses only underlying and not contributory causes of death aetiologically related to smoking. SAMMEC II estimates of smoking-attributable mortality are therefore conservative.

Analysis of 100 deaths reported by physicians - but not SAMMEC II - to be SADs, indicated that most of these deaths had at least one reported contributory cause that would have been recognised by SAMMEC II if it had been coded to the underlying cause. Analysis of 100 death certificates considered neither by SAMMEC II nor physicians to be attributable to smoking indicated that the listing of these contributory causes was not by chance. Therefore, although SAMMEC II's capacity to estimate SADs is limited by its inability to count all contributing causes of death, physician reporting is not. However, the physicians' reasoning for reporting a death as tobacco-related was not reflected on the death certificates that did not list a cause aetiologically linked to smoking (which represented 40 % of the non-SAMMEC II physician-reported SAD death certificates). Compared with death certificates that did mention a contributory cause recognised by SAMMEC II, physician-reported SAD death certificates that did not mention a contributory cause recognised by SAMMEC II listed fewer total contributory causes of death. This finding may reflect a reluctance by some certifying physicians to report fully all the patient's conditions. Alternatively, physicians may have misclassified some of these deaths, or fewer contributory causes were listed because persons dying from causes unrelated to smoking had fewer conditions to report.

Oregon, one of only five states that records information about decedents' smoking on death certificates,<sup>14</sup> had an opportunity to compare estimates derived from two different systems for measuring SADs. SAMMEC II relies on the scientific application of epidemiologically derived data to calculate the pro-

portion of deaths in the population attributable to smoking, but lacks the ability to consider all contributory causes of death. Physician reports rely on the opinion of respected professionals as to the causes of death for specific individuals, but may be limited by lack of knowledge about smoking-related illnesses. Despite the differences between SAMMEC II estimates and physician reporting of SADs, both systems provide remarkably similar estimates of SADs. As such, both can be used to communicate the risk of smoking to the public. The selection of an appropriate system may depend less on the precise numbers generated than on their credibility to specific audiences and their ultimate translation into public health measures.

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